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Research Article

Effects of Breed Differences and Parities on Milk Proximate and Mineral Compositions in Nigerian Cattle Breeds under the Extensive System

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ABSTRACT

Introduction: Milk production from indigenous cattle breeds in Nigeria represents an important component of the agribusiness sector of the smallholder economy with great economic, nutritional, and social implications.
Materials and methods: Three farms in the study location were chosen and 90 cows of three breeds of Sokoto Gudali, White Fulani, and Red Bororo in each farm, were used for the present study (total 270 cows). The cows of each farm were chosen equally based on parity (1-3). In this study, 5 ml of milk sample was collected from each cow in the morning for analysis of milk proximate and mineral composition. The analytical parameters included protein, fat, ash, moisture, calcium, iron, phosphorus, and sodium in milk.
Results: The results revealed that the parity of the three breeds significantly affected the milk proximate and mineral compositions. In the first parity, White Fulani cow milk was significantly higher in milk protein at 4.52%, followed by Red Bororo and Sokoto Gudali at 3.97% and 3.91%, respectively. Sokoto Gudali was significantly higher in milk fat at 3.18%, followed by Red Bororo at 2.89% and White Fulani at 2.76%. White Fulani was significantly higher in milk moisture at 84.56%, followed by Sokoto Gudali at 82.72% and Red Bororo at 81.13%. Red Bororo was significantly higher in milk phosphorus at 375.62 mg/L and sodium at 71.22 mg/L. In the second parity, only moisture, calcium, and sodium differed significantly among the breeds. White Fulani and Red Bororo were significantly higher in moisture at 83.75% and 83.43%, respectively. On the other hand, Sokoto Gudali were significantly higher in calcium at 614.94 mg/L and sodium at 68.76 mg/L. White Fulani and Red Bororo had significantly lower calcium levels at 560.50 mg/L and 555.42 mg/L, respectively. On the other hand, White Fulani had significantly lower levels of sodium at 61.25 mg/L. In the third parity, White Fulani was significantly higher in milk protein at 4.16%, calcium at 611.48 mg/L, and sodium at 75.33 mg/L. Red Bororo was significantly higher in fat at 3.75% and calcium at 626.99 mg/L. Sokoto Gudali was significantly higher in sodium at 75.36 mg/L. In overall, first parity cows were significantly higher in milk protein at 4.11%. Milk fat, ash, calcium, and sodium increased with number of parity. The third parity was significantly higher in milk fat (3.29%), ash (0.43%), calcium (599.58 mg/L), and sodium (71.77 mg/L) levels.
Conclusion: By increasing parity in Nigerian cows, the chemical composition of milk will be improved which can be considered for future studies on these breeds.

1. Introduction

Different animal species, such as dairy cattle, buffaloes, goats, sheep, and camels, dominate global milk production[1]. Cow's milk accounts for over 80% of the world's milk production[2]. Milk from different cattle breeds holds distinct compositions profile because of genetic background[3]. The chemical compositions of bovine milk

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and the protein-to-fat ratio are constantly being modified to meet consumer preferences[4]. Milk production from indigenous cattle breeds in Nigeria represents an important component of the agribusiness sector of the smallholder economy with great economic, nutrition, and social implications[5]. Among Nigerian breeds, Bunaji is recognized as the primary milk producer[6-8]. Nutritionally, milk has been regarded as the nearly perfect food because it provides more essential nutrients in significant amounts than any other single food. As a food, milk is vital for growth, reproduction, energy supply, maintenance, repairs, and appetite satisfaction in humans[9,10]. Milk is an outstanding source of calcium and phosphorus (for bone and teeth) and contains a significant amount of riboflavin and vitamins B6 and A[5]. Milk compositions vary from cow to cow and differ among breeds[5,10]. In dairy cows, parity can influence the metabolism, hormones, and metabolites following calving[8]. However, in most dairy research, there is a lack of information on the effect of parity on the milk proximate compositions of cattle. Thus, the present study aimed to investigate the effect of parity on milk proximate and mineral compositions in three breeds of Nigerian cows under an extensive system.

2. Materials and Methods

2.1. Ethical approval

The current study was conducted according to the guidelines of Animal Production and Health Faculty of Agriculture and Life Sciences Federal University, Wukari, Nigeria.

2.2. Location

The experiment took place in Maiduguri and its environments. Maiduguri, the capital of Borno State, is situated in Northeastern Nigeria. It lies between latitude 11^0 32' and 11^0 4' North and longitude 13^0 32' and 13^0 25' East with a mean annual rainfall of 200-250 mm (20). Maiduguri is located between the Sudan Savanna and Sahel Savanna vegetation zones, characterized by a short rainy season of 3-4 months (June-September) followed by a long dry season of 7-8 months.

2.3. Herd management

Under an extensive management system, the animals were free to graze on natural grassland pastures throughout the day. These pastures mainly consisted of Northern gamba grass (*Andropogon gayanus),* Stylo grass (*Stylosanthesgracilis*), and Leucaena grass (*Leucaena gracilis*), which are predominantly found in the study area.

2.4. Experimental animals and study samples

A total of 270 cows were randomly selected from three farms comprising three breeds including White Fulani, Sokoto Gudali, and Red Bororo. Each breed contained 90 cows, further subdivided based on parities of 30 cows in first, second, and third parity. About 5ml of milk was collected early in the morning by hand milking from all four quarters. Before feeding, 5 ml of the sample was bottled and stored in ice for laboratory analysis of milk proximate and mineral compositions in the University of the Wukari, Nigeria, laboratory. The milk protein and fat were analyzed by Kjeldahl and Gerber methods, respectively[11]. The mineral compositions, including calcium, phosphorus, iron, and sodium, were determined by atomic absorption spectrophotometer[12].

2.5. Data analysis

The data obtained from the study were subjected to analysis of variance as described in the procedure of the SAS program (SAS, 2000). The Duncan Multiple range test was used to determine significant mean differences. P value less than 0.05 was considered statistically significant, and the following model was used, $Y_{ij} = \mu + B_i + e_{ij.}$

Where, Y_{ij} is the observed values of ij^{th} of the breeds, μ denotes the overall mean, B_i signifies the fixed effect of i^{th} Breeds (i determines Sokoto Gudali, White Fulani, and Red Bororo), e_{ij} refers to random residual error.

3. Results and Discussion

The effect of the first parity on milk proximate and mineral compositions of Sokoto Gudali, White Fulani, and Red Bororo cows are presented in Table 1. The results showed a significant ($p < 0.05$) difference in milk protein, fat, moisture, phosphorus, and sodium in three cattle breeds. White Fulani was significantly higher in milk protein 4.52%, compared to Red Bororo and Sokoto Gudali (3.97% and 3.91 %, respectively, $p < 0.05$). White Fulani was also significantly higher in moisture, 84.56% over 81.13% and 81.72% for Red Bororo and Sokoto Gudali, respectively ($p < 0.05$). Red Bororo was significantly higher in phosphorus 375.62 mg/L and sodium 71.22 mg/L

Table 1. Effects of first parity on milk proximate and mineral compositions in White Fulani, Red Bororo, and Sokoto Gudali breeds located in Nigeria

Parameters	White Fulani	Red Bororo	Sokoto Gudali	SEM
Protein (%)	4.52^a	3.97^b	3.91^b	0.12
Fat (%)	2.76^b	2.89^b	3.18^a	0.5
Ash (%)	0.35	0.35	0.36	0.05
Moisture (%)	84.56^a	81.13^b	81.72^b	0.11
Calcium (mg/L)	571.06	585.05	549.33	0.47
Iron (mg/L)	1.03	1.01	1.02	0.05
Phosphorus (mg/L)	282.52^c	375.62^a	326.86^b	0.58
Sodium (mg/L)	49.62^c	71.22^a	51.91^b	0.12

^{abc}mean within the same row with different superscripts are statistically different ($p < 0.05$), mg: Milligram, L: Litre, SEM: Standard error mean

followed by Sokoto Gudali 326.86 mg/L for phosphorus and 51.91 mg/L for sodium ($p < 0.05$). However, White Fulani milk was lower at 282.52 mg/L of phosphorus and sodium 49.62 mg/L. Sokoto Gudali was significantly higher in milk fat at 3.18%, whereas White Fulani and Red Bororo were low and statistically the same at 2.76% and 2.89%, respectively ($p < 0.05$). The value of milk protein ranged 3.91- 4.52% obtained from the current study agreed with the range value of 3.72 - 4.01% for local cows in Sudan and Holstein Friesian in their first parity[13,14]. The ranged value of milk protein obtained from the present study was higher than 3.51% for Murrah buffaloes in their first parity[15], and also higher than 3.24% for Holstein Friesian in their first parity as reported in a study by Bonded et al.[8]. The variations in milk protein could be attributed to the animals' genetic makeup. The high range of milk protein in the present study could also be attributed to lower milk yield in three cattle breeds, which tend to increase the milk protein and vice versa. The findings imply that milk protein and yield might be controlled by different genes or inherited independently[15,16]. The range value of milk fat 2.76-3.18% obtained from the current study, which was higher than Sokoto Gudali and less than White Fulani cows, was lower than 3.77-5.16 % for local Sudan cows and Holstein Friesian in the first parity[15]. The variations in milk fat could be attributed to breed and feed, which could change the fatty acids produced in rumen fermentation. The higher the ratio of acetate to propionate in the rumen, the higher the fat content of the milk will be produced[13,17]. White Fulani milk showed significantly higher moisture content, whereas Red Bororo and Sokoto Gudali are lower and statistically the same at 81.13% and 81.72%, respectively ($p < 0.05$). Red Bororo was significantly higher in both phosphorus 375.62 mg/L and sodium 71.22 mg/L than Sokoto Gudali milk phosphorus 326.86 mg/L and sodium 51.91 mg/L and the least amount was from White Fulani milk with phosphorus 282.52 mg/L and sodium 49.62 mg/L. In the present study, the high value of phosphorus and sodium in Red Bororo could refer to breed differences and the low moisture content of the milk. The increased moisture content of the milk could increase the phosphorus and sodium concentrations[13,18].

Table 2 presents the results of the effect of second parity on milk proximate and mineral compositions of Red Bororo, White Fulani, and Sokoto Gudali. The results showed a significant difference in moisture, calcium, and sodium in the three breeds of cattle ($p < 0.05$). White Fulani and Red Bororo showed significant ($p < 0.05$) higherity in milk moisture at 83.75% and 83.75%, respectively, whereas 81.21% from Sokoto Gudali. The range value of milk moisture (81.21-83.71%) was lower than the recommended range of 84-88% for milk moisture in cows[19]. The results were also lower than 87.42, 87.17, and 86.58 for Muturu, White Fulani, and Red Bororo, respectively, as reported by Adesina[7]. The variations in the milk moisture could be ascribed to parity, season, and feed. The high milk moisture content is directly proportional to high water activity, which supports microbial growth, consequently decreasing the milk's shelf life.

Conversely, low milk moisture content implies low water activity, which causes the reduction of microbial growth and consequently increases milk's shelf life[19]. Regarding milk calcium, Sokoto Gudali showed a significantly higher level (614.94 mg/L, $p < 0.05$), while White Fulani and Red Bororo were lower and statistically the same in calcium at 560.50 mg/l and 555.42 mg/L, respectively. The present study's finding was in line with the report of Nantapo that breeds significantly affected selected milk minerals, such as magnesium, phosphorus, and calcium[12]. Calcium is important in bone formation, metabolism, muscle contraction, nerve transmission, and blood clotting. Calcium and phosphorus are required in large quantities for the rapid growth of neonates, bone growth, and the development of soft tissues. White Fulani and Sokoto gudali were significantly higher in sodium at 75.33 mg/L and 75.36 mg/L, respectively ($p < 0.05$). However, Red Bororo was lower in milk sodium 64.62 mg/L. could be associated with qualitative and quantitative traits. Sodium is a valuable electrolyte in maintaining water balance and blood volume.

As can be seen, the results of the effect of third parity on milk proximate and mineral compositions of White Fulani, Red Bororo, and Sokoto Gudali are presented in Table 3. The results showed that milk protein, fat, calcium, and sodium differed significantly ($p < 0.05$). White Fulani showed a significantly higher value in milk protein (4.16%, $p < 0.05$), whereas Red Bororo and Sokoto Gudali were lower and statistically the same in milk protein at 3.01% and 3.78%, respectively. The milk protein range of 3.01-3.78% obtained in the present study was higher than that of 3.26– 3.84% for local Sudan cows and Holstein Friesian in their third parity[13]. The aforementioned ranged value of the current study was also higher than 3.48 for Murrah

Table 2. Effects of second parity on milk proximate and mineral compositions in White Fulani, Red Bororo, and Sokoto Gudali breeds located in Nigeria

Parameters	White Fulani	Red Bororo	Sokoto Gudali	SEM
Protein (%)	3.93	3.64	3.55	0.5
Fat (%)	3.07	3.23	3.09	0.5
Ash (%)	0.37	0.35	0.37	0.8
Moisture (%)	83.75^{a}	83.43^{a}	81.21^{b}	0.6
Calcium (mg/L)	560.50^{b}	555.42^{b}	614.94^{a}	0.4
Iron (mg/L)	1.08	0.99	1.15	0.17
Phosphorus (mg/L)	361.54	310.01	314.25	0.01
Sodium (mg/L)	61.25^{c}	62.68^{b}	68.76^{a}	0.15

^{abc}mean within the same row with different superscripts are statistically different ($p<0.05$), mg: Milligram, L: Litre, SEM: Standard error mean

Table 3. Effects of third parity on milk proximate and mineral compositions in White Fulani, Red Bororo, and Sokoto Gudali breeds located in Nigeria

Parameters	White Fulani	Red Bororo	Sokoto Gudali	SEM
Protein (%)	4.16[a]	3.01[b]	3.78[b]	0.6
Fat (%)	2.96[b]	3.75[a]	3.15[a]	0.9
Ash (%)	0.46	0.40	0.43	0.08
Moisture (%)	85.25	84.00	82.08	0.02
Calcium (mg/L)	611.48[a]	626.99[a]	560.26[b]	0.42
Iron (mg/L)	1.23	0.84	1.23	0.01
Phosphorus (mg/L)	325.76	350.92	323.21	0.08
Sodium (mg/L)	75.33[a]	64.62[b]	75.36[a]	0.12

[abc]mean within the same row with different superscripts are statistically different (p<0.05), %: Percent, mg: Milligram, L: Litre, SEM: Standard error mean

buffaloes in their third parity[15]. The variations in the milk protein could be attributed to milk yield, breed, and species differences. Red Bororo and Sokoto Gudali showed significant (p < 0.05) higher in milk fat at 3.75% and 3.15%, respectively; however, White Fulani indicated the least value regarding milk fat (2.96%). The fat milk range of 2.96-3.75% obtained from the current study was lower than 5.14 for Sudan local cows in their third parity, whereas it agreed with 3.72 for Murrah buffaloes in their third parity[15]. The results of this finding on milk fat also were in line with a study by Adesina K., who opined that milk fat was significantly (p < 0.05) higher in Red Bororo 4.49, compared to White Fulani 3.60[2]. The variations in milk fat might be due to inherited characteristics[8]. White Fulani and Red Bororo were significantly higher in calcium, 611.48 mg/L, and 626.99 mg/L, respectively (p < 0.05). However, Sokoto Gudali milk indicated a low calcium level (560.26 mg/L). White Fulani and Sokoto Gudali were significantly higher in sodium 75.33 mg/L and 75.36 mg/L, whereas Red Bororo was lower in milk sodium 64.62 mg/L (p<0.05). The variations in the milk mineral composition might be attributed to the breed.

The results of the pooled effect of parity on milk proximate and mineral compositions of White Fulani, Red Bororo, and Sokoto Gudali are presented in Table 4. The results showed significant differences in milk protein, fat, ash, calcium, and sodium (p < 0.05). The first parity showed a significantly higher level of milk protein (p<0.05, 4.11%), whereas the second and third parities were lower in milk protein at 3.73% and 3.64%, respectively. The findings corresponded with a study by Shuiep et al.[14,] who opined that milk protein was higher in the first parity and then declined from the second parity. The present study was in line with the findings of a study conducted by Auldist et al.[19], who believed that milk protein tends to be higher in later parities in cows under natural pasture. The variation in milk protein in the present study can be attributed to parity. Cows in their first parity tend to produce lower milk yields, which in turn can result in higher milk protein concentrations compared to cows in their second and third parities. All the milk parameters (fat, ash, calcium, and sodium) in the current study grew with an increase in parity except the milk protein. This boost might be due to increased age and physiological organ maturity. Body weight and development of the udder during recurring pregnancies, which result in a larger mass of mammary glands for milk synthesis, could also be effective. Calcium growth due to increased parity might increase lactation, leading to high calcium demand for milk production[20].

Table 4. Effects of pooled parity on milk proximate and mineral compositions in White Fulani, Red Bororo, and Sokoto Gudali breeds located in Nigeria

Parameters	First Parity	Second Parity	Third Parity	SEM
Protein (%)	4.11[a]	3.73[b]	3.64[b]	0.7
Fat (%)	2.97[b]	3.14[ab]	3.29[a]	0.8
Ash (%)	0.35[b]	0.36[b]	0.43[a]	0.01
Moisture (%)	82.40	82.99	83.78	0.28
Calcium (mg/L)	566.56[b]	572.20[ab]	599.58[a]	6.00
Iron (mg/L)	1.02	1.05	1.10	0.02
Phosphorus (mg/L)	328.18	330.40	339.07	1.82
Sodium (mg/L)	57.04[b]	63.66[b]	77.77[a]	10.03

[abc]mean within the same row with different superscripts are statistically different (p<0.05), %: Percent, mg: Milligram, L: Litre, SEM: Standard error mean

4. Conclusion

In conclusion, the present study showed a significant effect of parity on milk proximate and mineral compositions in White Fulani, Red Bororo, and Sokoto Gudali cows. The parity efficiently increased from parity 1 to 3 in all the parameters except milk protein, which was high in the first parity. The dairy industries could use present findings to select and plan breeding programs for these breeds.

Declarations

Competing interests

The authors have declared that no competing interests exist.

Authors' contributions

This work was carried out in collaboration with the authors. Ayuba Dauda designed and coordinated data

collection. Philip John Ahmadu wrote the protocol performed the analysis, and managed the analyses of the study. Yusuf Idi wrote the first draft. All authors read and approved the final manuscript draft.

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Availability of data and materials

Data and Materials used were available.

Ethical considerations

Ethical issues, such as data fabrication, double publication and submission, redundancy, plagiarism, consent to publish, and misconduct, have been checked by all the authors before publication in this journal.

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